

## **Maximum Oxygen Uptake during and after Long-Duration Space Flight**

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### **INTRODUCTION**

Decreased maximum oxygen consumption ( $\text{VO}_2\text{max}$ ) during and after space flight may impair a crewmember's ability to perform mission-critical work that is high intensity and/or long duration in nature (Human Research Program Integrated Research Plan Risk 2.1.2: Risk of Reduced Physical Performance Capabilities Due to Reduced Aerobic Capacity). When  $\text{VO}_2\text{max}$  was measured in Space Shuttle experiments, investigators reported that it did not change during short-duration space flight but decreased immediately after flight. Similar conclusions, based on the heart rate (HR) response of Skylab crewmembers, were made previously concerning long-duration space flight. Specifically, no change in the in-flight exercise HR response in 8 of 9 Skylab crewmembers indicated that  $\text{VO}_2\text{max}$  was maintained during flight, but the elevated exercise HR after flight indicated that  $\text{VO}_2\text{max}$  was decreased after landing. More recently, a different pattern of in-flight exercise HR response, and assumed changes in  $\text{VO}_2\text{max}$ , emerged from routine testing of International Space Station (ISS) crewmembers. Most ISS crewmembers experience an elevated in-flight exercise HR response early in their mission, with a gradual return toward preflight levels as the mission progresses. Similar to previous reports, exercise HR is elevated after ISS missions and returns to preflight levels by 30 days after landing.  $\text{VO}_2\text{max}$  has not been measured either during or after long-duration space flight. The purposes of the ISS  $\text{VO}_2\text{max}$  experiment are (1) to measure  $\text{VO}_2\text{max}$  during and after long-duration spaceflight, and (2) to determine if submaximal exercise test results can be used to accurately estimate  $\text{VO}_2\text{max}$ .

### **METHODS**

ISS crewmembers assigned to missions of >90 days duration may volunteer for this study. About 270 days before launch, crewmembers perform a graded exercise test (identical to the MedB4.1 protocol) to volitional fatigue on a cycle ergometer to measure  $\text{VO}_2\text{max}$ . An individualized test protocol based on the results of this test is developed for all subsequent exercise tests. The test protocol begins with three 5-minute exercise stages designed to elicit 25%, 50%, and 75% of preflight  $\text{VO}_2\text{max}$  and continues with 25-watt/min increases until volitional fatigue. Metabolic gas analysis is performed using the Portable Pulmonary Function System (PPFS, DAMEC Research ApS, Odense, DK). Cardiac output is measured by the PPFS using a rebreathing technique ( $\text{R-22/SF}_6$ ) during the final minute of each of the first three exercise stages. These tests are scheduled to be performed 60 and 30 days before launch, monthly during flight, and on recovery days 1, 10, and 30.

### **RESULTS AND DISCUSSION**

At the time of abstract submission, 4 crewmembers were participating in the study but had not completed their respective missions. Unfortunately the PPFS could not be delivered to the ISS in time to support early flight test sessions on 3 of 4 crewmembers, but all crewmembers will complete at least 2 test sessions during flight. These sessions were successfully conducted with only minor issues. By the time of the conference presentation it is anticipated that at least partial sets from 3 of the crewmembers will be available for presentation and discussion.